CEMENT AND LIME MANUFACTURE

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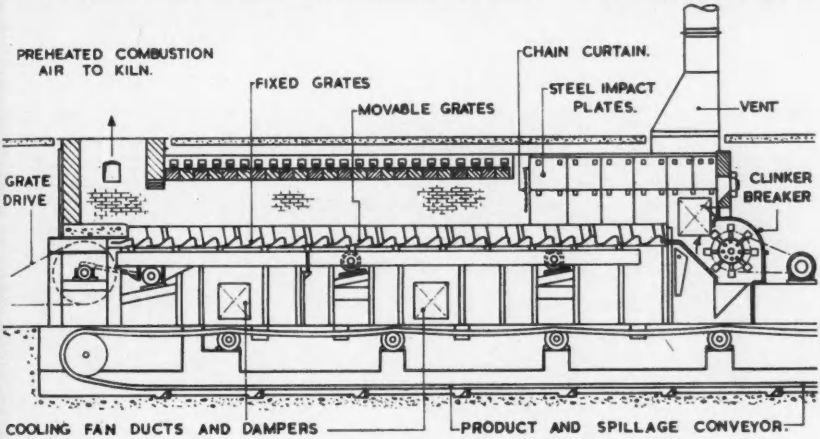

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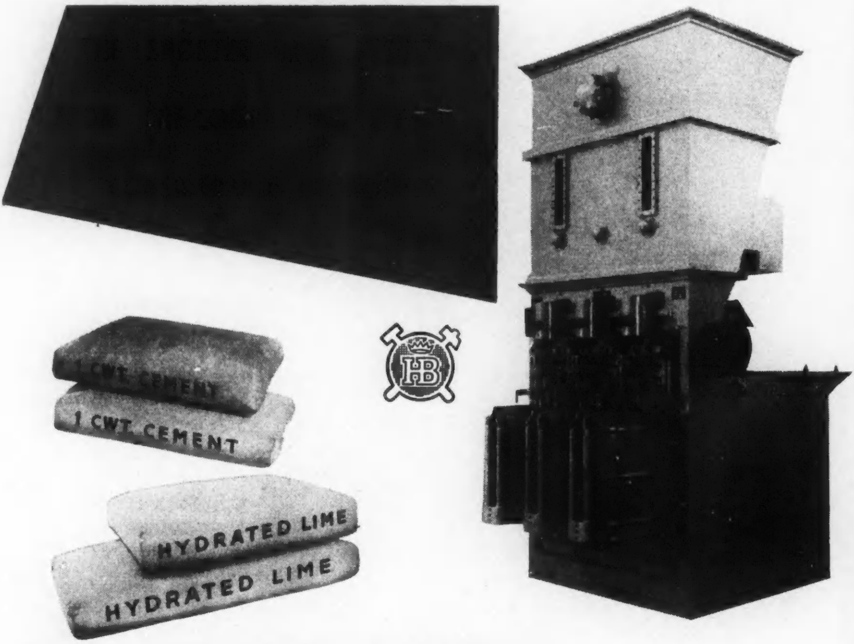

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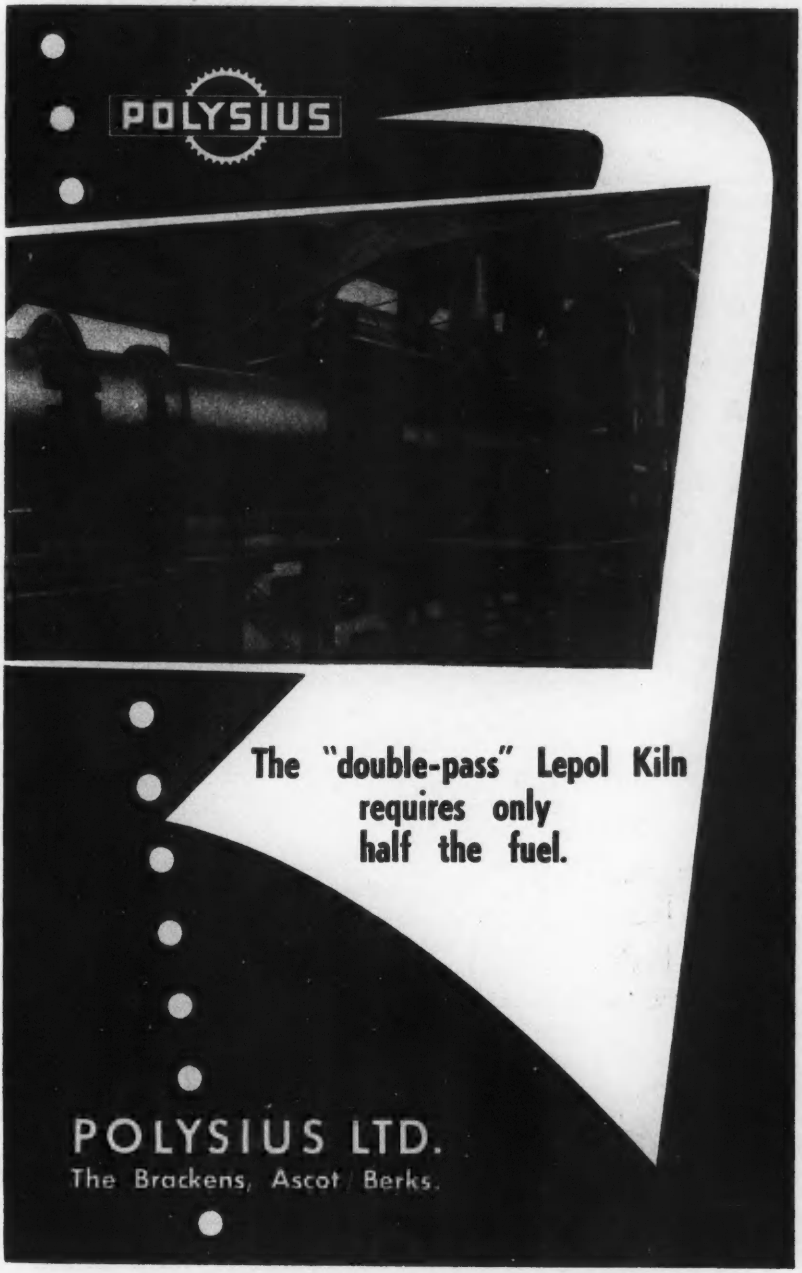
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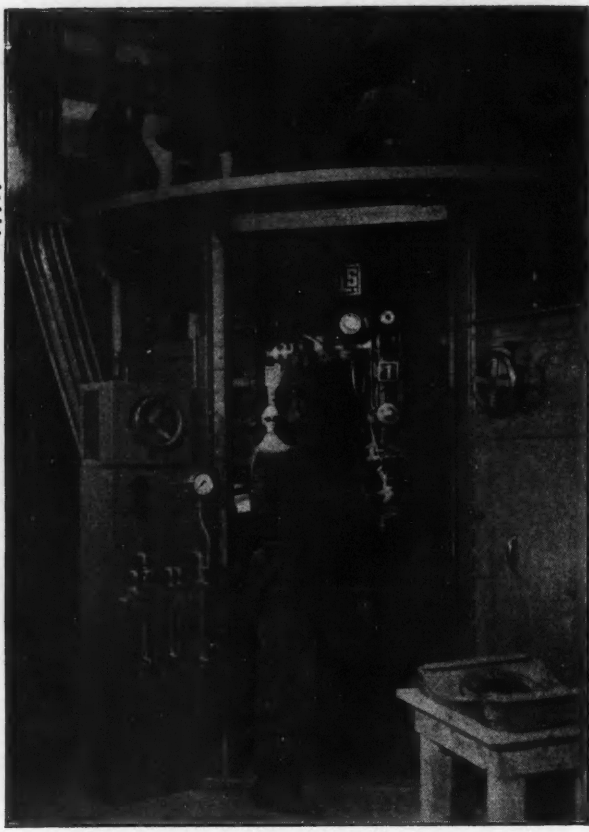

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MANUFACTURE

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Filtration in the Cement Industry.

In the year 1954 the Associated Portland Cement Manufacturers, Ltd., started to investigate the possibility of using a semi-dry slurry in order to save the cost of evaporating the water in wet-process kilns. After studying various methods of filtration it was decided to experiment with a multiple-plate horizontal filter-press, which was considered to be the only process by which the moisture content of the slurry could be sufficiently reduced to provide a solid capable of being formed into nodules suitable for burning in a kiln. It appeared that by this process a very great output of slurry-cake could be obtained, and a high degree of mechanisation also appeared to be possible.

The largest size of pressure-type batch filter used in the pottery industry produced a filter-cake (or slab) a little larger than 2 ft. 6 in. square and only slightly over 1 in. in thickness; such small filter-cakes would have required so many presses and so much labour that they would not have been economical in the cement industry. It was considered, therefore, that in the initial stages presses capable of making between 10 tons and 11 tons of filter-cake per operation were the economical minimum. These presses are 4 ft. square and produce filter-cakes having a thickness of 1⅞ in. The mechanical equipment was designed for removing such heavy filter-cakes, and a plant was installed at the Company's works at Shoreham in June, 1955, some seventeen months after the decision to start the experiments.

The plant comprises a large number of metal plates placed vertically one against another in a horizontal row (*Fig.* 1). Both faces of each plate are recessed and are covered by a backing cloth on which nylon cloth is placed. A space is formed between the backing cloth and the plates by means of small ribs on the plates. The plates are clamped tightly together, and the slurry is pumped under pressure into the row, passing through an aperture in the centre of each plate and the cloths. The water percolates under pressure through the cloths into the space between the cloths and the plates, and drains out through small ducts in

the edges of the plates (*Fig.* 2). Pumping ceases when all the recesses between the plates are filled with compressed slurry, and the plates are automatically spread apart, thus allowing the filter-cakes to fall on to a conveyor below the press.

Research on the optimum pressure of filtration, the effect of the temperature of slurry on the rate of filtration, and similar problems showed that the problem of filtration in the cement industry was very different from that in the pottery industry. After experimenting with many other materials it has been found that the most economical filter-cloth is woven nylon weighing 12½ oz. per square yard, as is shown in the following:

Hydraulic twill: Early failure due to cutting when creases in the cloth were compressed between the sealing faces of the plates.

P.V.C.: Failure due to open weave causing a very cloudy filtrate, and to "blowing".

Polythene: Failure due to open weave allowing slurry to pass through and form a cake on the backing-cloth.

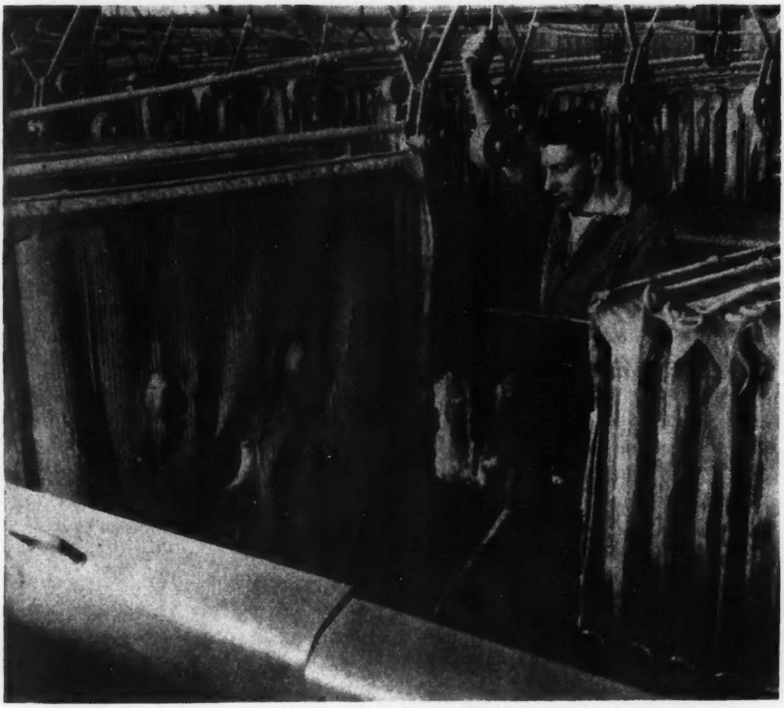

Fig. 1.—The Filter Plates.

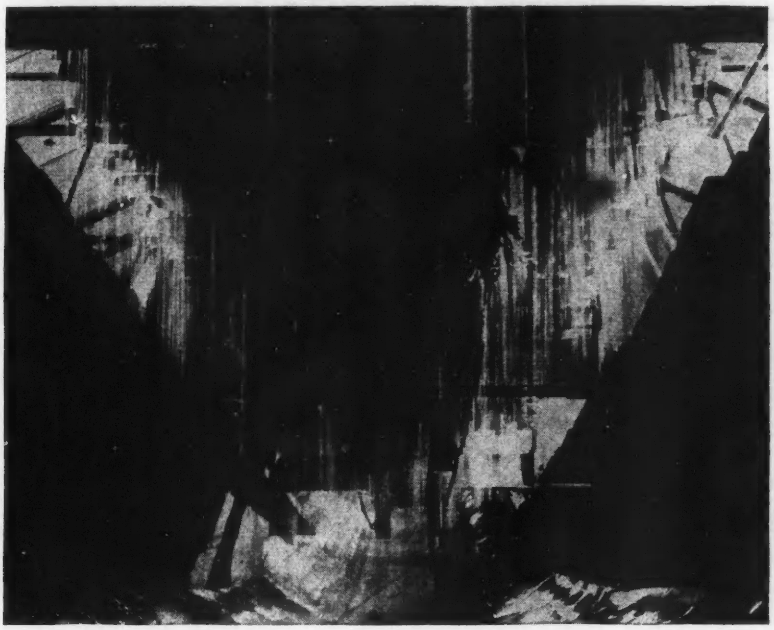

Fig. 2.—Water Draining from Filters.

12½-oz. nylon: Average life 3000 pressings.

17-oz. nylon: No improvement over 12½-oz. nylon, taking cost into consideration.

7-oz. nylon: Shorter life than 12½-oz. nylon.

The backing-cloths first used to protect the nylon filter-cloths from the metal of the press-trays were made of jute, and had only a short life. Various thicknesses of this material, proofed and otherwise, were tried but the results were still uneconomical. Many other materials were tried as shown in the following, but gradual improvement has been obtained and, as will be seen, the durability of P.V.C. has been almost quadrupled.

Jute (proofed and otherwise and jute treated with neoprene): Soon cut and rotted; Average life 800 pressings. Unbleached flax: Failure due to clogging of the flax after 100 to 150 pressings. Thick woven sisal: Average life 1400 pressings. Cotton duck: Satisfactory; average life 2000 pressings. P.V.C. with rubberised edges: Very satisfactory; average life more than 3000 pressings. Plain P.V.C.: Very satisfactory; average life 3000 pressings. P.V.C. with nylon surround: Very satisfactory; full life not yet known.

In addition to the general wear and tear of the filter and the backing-cloths

serious cutting also took place during the opening and closing of the press due to the meeting faces of the plates being of small area. Attention was therefore given to a new design of press-plate with such success that it is impossible to say what the working life of the filter and the backing-cloth will be.

As a result of this experience the Company is installing similar filtration plants for some of its larger kilns, and also at new works. Larger presses have therefore been designed which will produce 24 tons of slurry-cake per pressing, and designs are being prepared for presses with double this capacity. In such presses the maximum thrust on the ends will be several hundred tons. An interesting feature is that, due to the experience gained, the weights of the supporting structures and plates increase at only half the rate of the increase in production.

Many types of slurries from other of the Company's works have been tested at the Shoreham works, first in laboratory-size test apparatus and later in full-scale production. The accuracy of the laboratory tests has been fully borne out in production.

In general it has been found that hard granular materials can be filtered very easily but will not produce a filter-cake which has sufficient plasticity to be made into nodules. At the other extreme, raw materials which produce a very viscous or ultra-colloidal slurry require a longer time for filtration, and are uneconomical due to excessive capital outlay for plant. Raw materials with characteristics between these two extremes are the most suitable for this class of filtration. The range of filtration times with different classes of raw materials can vary from a few minutes to several hours, with thicknesses of cake of 6 in. in the case of the most rapid filtration to less than 1 in. in the case of the most difficult materials for filtration.

Although the nylon filter-cloths are a very important factor, the escape of the water from the slurry is dependent on the cloth for only the first minute or so. As soon as a thin layer of semi-dry slurry is deposited on the cloth it acts as the filtering medium, and the cloth then becomes merely a container for the cake. Thus the cake is built up from the outside towards the centre, and if it is insufficiently filtered the centres of the cakes will be soft or even liquid. A good filter-cake will have a uniform moisture content throughout its thickness. The efficiency of filtration is very high with 12½-oz. nylon, as the amount of solids in the filtrate is only about ¼ lb. per ton of water. The pressure at which the cake is produced is also important, and generally is about 120 lb. per square inch. Above this pressure there is a tendency for the materials to segregate so that the inner layers of cake contain a higher content of carbonate than the outer layers.

Proposed Cement Works in Peru.

Cementos Arequipa S.A. proposes to build a cement works in Peru at a cost of 3,296,000 U.S. dollars.

Cement Works in Honduras.

A cement works near San Pedro Sula, the first to be built in Honduras, started production in June last. The capacity of the works is 10,000 tons a month.

Experiments on Portland Cement Pastes.

THE Cement and Ceramics Section of the Commonwealth Scientific and Industrial Research Organisation (P.O. Box No. 4331, Melbourne, Australia) has issued a report of an investigation by Mr. K. M. Alexander and Mr. J. Wardlaw into a micrometer method for measuring the changes in volume and weight of thin layers of Portland cement paste during carbonation and drying without disturbing the curing process.

The authors state that one of the major obstacles encountered in studying the effect of carbonation and drying on the volume stability of hydrated Portland cement is the slowness with which these processes take place at even a short distance beneath the surface of the relatively large specimens used in many investigations. Theoretically the errors caused by the cracking, differential shrinkage and incomplete equilibrium associated with this impermeability of the specimen could be eliminated by working with much smaller test-pieces. However, there are some practical difficulties which must first be overcome. Reduced-scale experiments require, for example, improved accuracy of measurement if sensitivity is not to be impaired and, in addition, the results are more prone to errors caused by short-term disturbance of curing conditions. The procedure described reduces these errors. The cross-sectional area of the test-pieces is only 0·015 sq. in., compared with cross sections of 1 sq. in. to 40 sq. in. generally used.

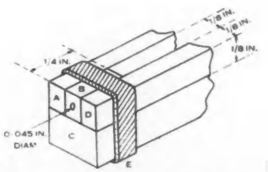

Fig. 1.—Mould for Casting Specimens.

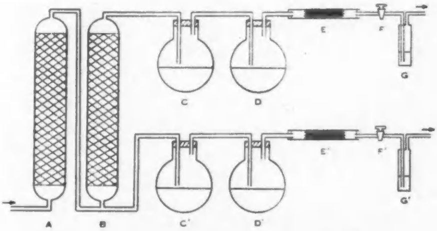

Fig. 2.—Arrangement of Scrubbing Towers, Hydrators and Curing Tubes.

PREPARATION AND INITIAL CURING OF SPECIMENS.—Portland cement paste specimens ⅛-in. square in cross section are cast in the small moulds illustrated in *Fig.* 1. Each mould consists of two side pieces of brass 3 in. long and ⅛-in. square (*A* and *D*) separated at each end by a brass spacer (*B*) ⅛-in. square and ¼ in. long. A narrow hole is drilled through each spacer to accommodate the end-points of the bar. The spacers and side-pieces are held down on the baseplate (*C*) by rubber bands (*E*). The bars produced in the moulds are 2½ in. long and ⅛-in. square in cross section, and have end-points ½ in. long embedded in each end a distance of ¼ in. Nichrome wire of 0·04 in. diameter (B.S.W.G. 19) is suitable for making the end-points. When they are filled with Portland cement paste the moulds are placed in close-fitting test tubes which are sealed and stored for 24

hours at the required temperature. On removal from the moulds the specimens are weighed, measured, and cured in water. At the end of the curing period the specimens are again measured and weighed and transferred to the apparatus for carbonation and drying.

CARBONATION AND DRYING.—Six or more specimens of each type of paste are divided into two equal groups and placed on wire racks in the tubes *E,E'* of the carbonation and drying apparatus (*Fig.* 2). By applying a partial vacuum to bubblers *G,G'* air is drawn through the trains at a rate controlled by taps *F,F'*. On entering the train, the air is dried over silica gel in tower *A*, and then either scrubbed free from carbon dioxide in tower *B* or passed directly to humidifiers *C',D'* containing saturated salt solutions. Gravimetric determinations were made of the relative humidity of the air leaving humidifiers of many different designs. From these experiments the arrangement of inlet and exhaust tubes shown for litre flasks *C,C',D,D'* was found to be the most efficient at the aspiration rates used; also the chance of carrying salt spray over to tubes *E,E'* was negligible. The equipment is illustrated in *Fig.* 3, which shows an apparatus for delivering eight different curing atmospheres simultaneously, namely, normal air and carbon dioxide free air at four different relative humidities.

THE COMPARATOR.—The comparator (*Fig.* 4) consists of a heavy cast base on which a large drum micrometer (*I*), fiducial indicator (*M*), and measuring chamber (*F*) are mounted. The micrometer is directly marked in intervals of 0·0001 in.,

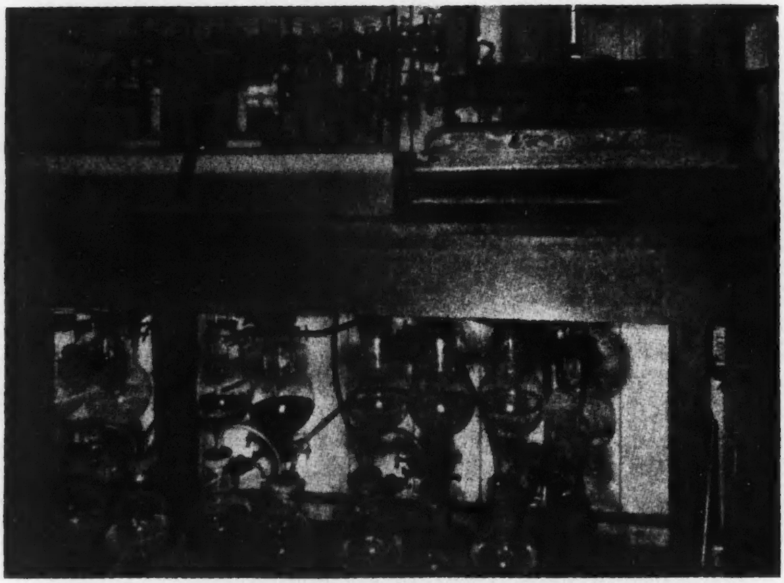

Fig. 3.—The Comparator, the Measuring Chamber, and the Apparatus for Generating Controlled Atmospheres.

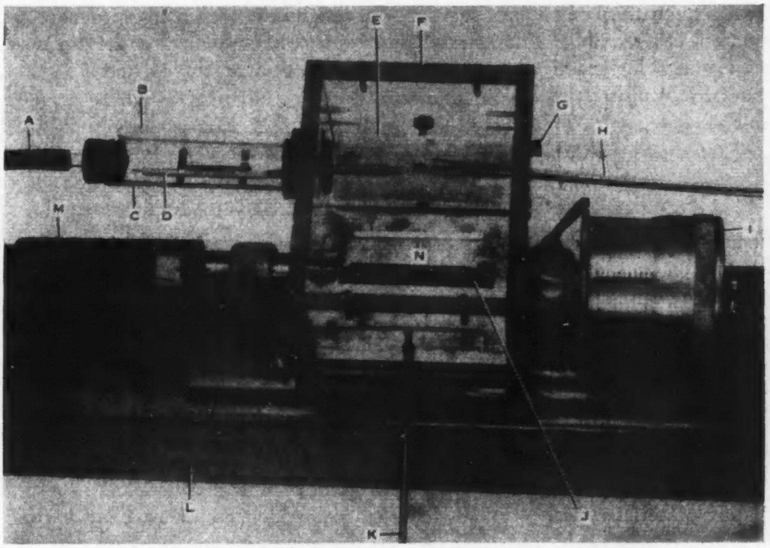

Fig. 4.—Micrometer Comparator and Controlled-Atmosphere Measuring Chamber.

and is operated at a 4-oz. measuring pressure as registered by the fiducial indicator.

METHOD OF OPERATION.—The Perspex measuring chamber (*F*) (*Fig.* 4) is first filled with air with the required content of carbon dioxide and water vapour. The curing-tube (*C*), containing specimens such as (*D*), is then transferred from the curing train and plugged into the measuring chamber as shown, whilst a current of air of the correct content of carbon dioxide and water vapour is passed in through inlet tube (*A*). The specimens are withdrawn from tube (*C*) and placed on platform (*E*) by means of the probe (*H*), the jaws of which can be clamped on to the end-point of the specimen by manipulating a steel rod inside the outer glass sheath of the probe.

Before measurements are made the micrometer zero is checked with a stainless-steel distance piece (*N*) stored inside the measuring chamber, and placed on the vee-shaped block (*J*) by the lifting fork (*K*). When the zero has been checked the specimens are transferred from platform (*E*) to the vee-block (*J*) by the fork (*K*), measured, and returned to the platform. Platform (*E*) is then raised to the level of tube (*B*), and the probe is transferred to hole (*G*) where it is used for placing the specimens, one at a time, in tube (*B*) which has previously been weighed. Tube (*B*), containing a single specimen is then sealed, weighed, and returned to its position on the measuring chamber. When all the specimens have been weighed they are returned to tube (*C*) and to the curing train by reversing the procedure described.

Although the equipment illustrated is designed for studying specimens ⅛-in. square it can readily be adapted for use with smaller specimens if the dimensions of the measuring chamber and associated equipment are changed, and if a suitable fiducial indicator is installed.

Loss on Ignition of Portland Blastfurnace Cement.

In an introduction to a report of an investigation of methods of determining the loss on ignition of Portland blastfurnace cement, Mr. Bernard Chaiken, of the U.S.A. Bureau of Public Roads, states that the procedure used to determine the loss on ignition of Portland cement is not applicable to Portland blastfurnace cement because of the oxidation of the sulphide constituents. This causes low results to be obtained which are not valid measures of the contents of moisture and carbonaceous material. Several modified procedures were investigated and the validity of each was established by comparison with the results obtained by direct determinations of carbon dioxide and water contents. The methods studied included the recently-revised procedure of the American Society for Testing Materials which provides for a correction for sulphide oxidation, and a procedure developed in this study which involves ignition in a helium atmosphere. The revised A.S.T.M. procedure and the helium method gave accurate and reproducible results. The helium procedure, however, has the advantage of being more rapid since additional sulphur trioxide determinations are not required, and it is recommended for laboratories making frequent analyses of Portland blastfurnace cement.

The procedure involves ignition for fifteen minutes at about 950 deg. C. in a Rose crucible which is continuously flushed with helium gas at a constant rate of flow. The variations employed differed only in the rate of the flow of gas and the length of time the crucible and its contents were flushed with gas before and after ignition. During these determinations it was generally observed that a second ignition of the same sample of Portland blastfurnace cement usually produced a slight increase in weight of the ignited cement, rather than a constant or slightly lower weight. This was attributed to a slight tendency for oxidation of sulphides to occur even in the inert atmosphere of helium. However, such limited oxidation does not markedly affect the results.

The results of the investigation are given in full in the Bulletin of the American Society for Testing Materials for May, 1959.

New Lime Kilns in the Dominican Republic.

Plans are nearing completion by Industrias Nigua, C.por.A., for the installation in San Cristobal of lime kilns costing about £250,000.

Concrete Containing Pulverised-Fuel Ash.

MORE than 82,000 cu. yd. of concrete containing pulverised-fuel ash (fly-ash) were used in the construction of the Lednock dam in Scotland. Consequently a considerable amount of data on this material was obtained and is given by Mr. A. C. Allen in the Proceedings of the Institution of Civil Engineers for July 1959. (The use of pulverised-fuel ash as an aggregate in Poland was described in this journal for January 1959, and a note on research on this material undertaken by the Building Research Board is given in this journal for September 1958.)

The crushing strength of ordinary Portland cement concrete for this dam was required to be not less than 2800 lb. per square inch at 28 days. Since concrete containing pulverised-fuel ash attains strength more slowly than does ordinary Portland cement concrete, it was specified that the crushing strength should be not less than 2000 lb. per square inch, which was considered to be the lowest strength acceptable at 28 days if the strength at the end of a year was to be the same as that of concrete without pulverised-fuel ash. The amount of ash was 20 per cent. of the quantity of the cement required in the ordinary concrete and the quantity of cement was reduced by this amount, with a consequent saving in cost.

Preliminary tests showed that at 28 days the strength of concrete containing pulverised-fuel ash might be 81 per cent. of the strength of concrete without ash but of equal workability. Increase in the carbon content of the ash was shown to correspond to a reduction in strength of the concrete and was the cause of the average strength of works-cubes being only 76 per cent. of that of works-cubes of the concrete without ash. It was to allow for this variation that the minimum strengths of works-cubes at 28 days were required to be 71 per cent. of the minimum specified for concrete without ash.

The variation of strength of concrete containing ash is not considered to be caused by variation of the carbon content only, nor is it thought that the magnitude of any change of strength would be the same for Portland cements of different chemical compositions. As the carbon content increased so generally did the quantity of iron oxide and combined sulphuric acid, but there was a reduction in the amounts of silica and alumina.

The fineness of the ash appeared to have no relation to the carbon content or to the strength of the concrete. The ash used for this dam was obtained from a power station at Braehead on the River Clyde, and the specific surface varied from 2000 to 3000 sq. cm. per gramme. The usual method of expressing fineness as specific surface is not considered satisfactory for pulverised-fuel ash since similar results are obtainable for samples which are visibly different. Specific surface does not appear to have a consistent relation to any other property of the ash, although the size, shape, and surface characteristics of the particles are considered to affect workability and strength. Different air-permeability methods of determining the specific surface give different results for the same

ash, and other methods, such as low-temperature gas adsorption, may give entirely different results. It is suggested that a new method of measuring the fineness of ash should be sought.

Another advantage of replacing some of the cement in concrete by pulverised-fuel ash, in addition to less cost and increased workability, is a reduction in the heat of hydration which is of considerable importance in large masses of concrete as in a dam.

Patent Applications Relating To Cement.

Composition of Cement.

Clinker containing more than 6 per cent. of magnesia and of a petrographic composition of 55 to 59 per cent. C_3S, 7·55 to 8·56 per cent. C_4AF, and 4 to 6 per cent. C_3A is baked at 1,370 deg. to 1,450 deg. C., rapidly cooled, and ground with siliceous material containing active silica in such proportions that periclase in the clinker reacts to form magnesium hydrosilicates. Pulverised-fuel ash (fly ash) is the specified siliceous material. No. 814,749. J. Rosa. April 13, 1956.

White Cement.

White cement is produced by subjecting the clinker to reduction for 30 to 60 minutes at above 900 deg. C., cooling slowly in an inert or reducing atmosphere to 700 deg. C. or less, and finally rapidly quenching. The reducing and cooling treatments can be carried out in a single stage. Quenching may be by air, water, or steam. The process can be carried out on already prepared white cements to make them whiter.—No. 814,836. Dyckerhoff Portland-Zement Werke A.G. September 18, 1956.

Blastfurnace Cement.

Cements of high early strength increasing progressively with time comprise a high proportion of finely-ground granulated blastfurnace slag mixed with a small proportion of anhydrous sodium sulphate (about 4 per cent. by weight) and a small proportion of either hydrated lime (about 2 per cent. by weight) or Portland cement clinker (about 5 per cent. by weight).—No. 813,084. Soc. Financiere de Transports et d'Enterprises Industrielles (Sofina), S.A. September 2, 1957.

Oil-Well Cement.

A pumpable cement slurry suitable for cementing bore holes is prepared by mixing an aqueous liquid with an hydraulic binder comprising one or more finely-divided quickly cooled basic blastfurnace slags substantially free from activators and devoid of setting properties under atmospheric conditions. Preferably at least 50 per cent. of the slag particles are smaller than 20 microns. From 20 to 70 per cent. of a finely divided non-setting substance, for example quartz, pozzolana, slate, or bentonite can be included in the binder to delay setting, as also can acid salts, for example ammonium chloride. The preferred water : slag ratio for the slurry is 0·4.—No. 793,268. Naamlooze Vennootschap de Bataafsche Petroleum Maatschappij. November 10, 1955.

The Cement Industry in Europe.

THE Organisation for European Economic Co-operation has issued a report entitled "The Cement Industry in Europe, 1958 Statistics" which is obtainable in Great Britain from H.M. Stationery Office (price 6s.) or from the office of the Organisation at 2, Rue André-Pascal, Paris 16. The Organisation comprises the following member countries: Austria, Belgium, Denmark, France, Federal Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Sweden, Switzerland, Turkey, and the United Kingdom. The statistics given include cement made from imported clinker but exclude clinker which was exported unground.

The total production of cement in the member countries during the year 1958 was 76,900,000 tons, which was 1,400,000 tons more than in the year 1957, whereas there had been small declines in the rate of increase during the previous three years. Compared with the year 1957 production decreased by 2·5 per cent. in the United Kingdom; there were increases of 7 per cent. in France, 6 per cent. in Italy, and 3 per cent. in Federal Germany. Member countries produced 30 per cent. of the total world production of cement, of which Germany produced 7·7 per cent., France 5·4 per cent., Italy 5·1 per cent., and the United Kingdom 4·5 per cent. The proportions of world production by other than by member countries were as follows: America 29 per cent., other European countries 23 per cent., Asia 14 per cent., Africa 3 per cent., and Oceania 1 per cent.

During the year 1958 six cement works were built in member countries. Of these two are in Turkey each with a rotary kiln, with a total capacity of 170,000 tons annually; one with a rotary kiln is in France with a capacity of 280,000 tons annually, one with a rotary kiln with a capacity of 40,000 tons annually is in Denmark; one with a vertical kiln is in Switzerland, with a capacity of 110,000 tons annually; and one is in Iceland with a rotary kiln with a capacity of 105,000 tons a year; this is the first cement works in Iceland. In existing works in member countries twenty-four new kilns were built, including one vertical kiln in France and one in Austria with an annual capacity of 25,000 tons. The others are rotary kilns, of which four are in Federal Germany with an annual capacity of 750,000 tons; one is in Belgium with an annual capacity of 300,000 tons; nine are in France with an annual capacity (including that of the vertical kiln) of 700,000 tons; two are in Italy with a yearly capacity of 200,000 tons; one is in the United Kingdom with an annual capacity of 102,000 tons; and two are in Switzerland with an annual capacity of 160,000 tons.

The number of people employed in the industry in member countries during the year 1958 was reduced by 2,000; of these 600 were clerical or administrative staff. The number of people employed in the industry in the United Kingdom during the year 1958 was 15,500, a reduction of 1,100 of whom 300 were clerical or administrative staff. The average production per man employed in member countries rose from 800 tons in the year 1957 to 826 tons in the year 1958.

Exports to non-member countries during the year 1958, at 3,170,000 metric tons, were 16 per cent. less than in the previous year, a reduction of 620,000 tons.

About 4·1 per cent. of the total production was exported compared with 4·9 per cent. in the year 1957. Imports from non-member countries were reduced by 368,000 tons (76 per cent.).

Trading in clinker during the year amounted to about 250,000 tons; 80,000 tons were exported to the oversea territories of member countries and 14,000 tons were imported from non-member countries; the United Kingdom imported 95,000 tons of clinker from Ireland.

The total consumption of cement in the member countries was 73,900,000 tons, which was about 2·4 per cent. more than in the year 1957. The increase was mainly in Federal Germany (1,100,000 tons; 6·1 per cent.), France (700,000 tons; 5·7 per cent.), and Italy (700,000 tons; 5·6 per cent.). Slight increases in consumption also occurred in Austria, Greece, Iceland, Portugal, and Sweden, but in all other member countries consumption decreased; in the United Kingdom consumption decreased from 10,871,000 tons to 10,714,000 tons.

The average price of ordinary (or standard) cement in Denmark decreased by 2·5 per cent. and in France by 12·5 per cent.; prices increased in Greece by 12·9 per cent., in Norway by 1·4 per cent., in Portugal by 2·3 per cent., and in the United Kingdom by 3·5 per cent. There were no changes in Federal Germany, Belgium, Italy, the Netherlands, Sweden, and Switzerland. The prices are for loose cement at works except in the case of the United Kingdom where the prices include packing in 1-cwt. bags and delivery to Central London. The average prices of ordinary (or standard) Portland cement in the various countries were as follows in terms of U.S.A. dollars per metric ton: Federal Germany 12·60, Belgium 11·89, Denmark 11·07, France 11·67, Greece 16·66, Iceland 20·55, Italy 12·88, Norway 13·66, Netherlands 11·78, Portugal 16·29, Sweden 12·92, Switzerland 13·83; the foregoing are the prices of unpacked cement at works. The price in the United Kingdom is given as $15·47 including delivery to Central London packed in 1-cwt. bags.

It is intended to build six new works in Italy with a total of seven rotary kilns with a combined annual capacity of 1,500,000 tons, but it is likely that some of these works will not be completed until after the year 1960. In Turkey it is expected that production will begin during the year 1959 at two works with a total annual capacity of 170,000 tons, and in the year 1960 at three works with a total capacity of 320,000 tons yearly.

In 1958 there were plans for the installation of eighteen new kilns in existing works in the member countries during the years 1959 and 1960. The estimated increase in annual capacity is 3,000,000 tons. The number of kilns and their total annual capacity are as follows: Belgium: one, 300,000 tons; France: six, 500,000 tons; Italy: four, 850,000 tons; Denmark: one, 50,000 tons; Greece: three, 487,000 tons; Portugal: two, 704,000 tons; United Kingdom: one, 76,000 tons. It is estimated that by the end of the year 1959 the total annual capacity of member countries will be about 94,095,000 tons and by the end of 1960 about 95,700,000 tons; in the case of the United Kingdom the annual capacities expected are 14,100,000 tons at the end of both 1959 and 1960.

Research on Cement.

THE following is abstracted from the annual report of the Building Research Board of the Department of Scientific and Industrial Research. The document is entitled "Building Research 1958," and is published by H.M. Stationery Office at 5s. 6*d*.

Cement and Silicate Chemistry.

By arrangement with Uganda Cement Industries, Ltd., work on cement made from phosphate-bearing raw materials included research on the phase equilibria at high temperatures in the system $CaO—SiO_2—P_2O_5$, and the first instalment, a study of the system $2CaO.SiO_2—3CaO.P_2O_5$ has been completed. The elucidation of this system owes much to complementary methods using microscopy and X-ray diffraction at high temperatures, and making use of the heated-thermocouple principle described in previous reports. The high-temperature X-ray method has been improved during the year so that it is now possible to reach a maximum working temperature of 1850 deg. C.

The high-temperature microscope is currently being applied to phase-equilibrium studies relating to cement and slag, mainly in portions of the quaternary system $CaO—Al_2O_3—SiO_2—MgO$. This instrument is produced commercially.

A D.S.I.R. Research Fellowship has been established to study the structure of hydraulic glasses. Certain slags from blastfurnaces, when rapidly cooled in water, form a glass substance which is the basis of useful cementing materials, for example, Portland blastfurnace cement and supersulphate cement. It is known empirically that some slags will make good cements whilst others will not. The object of the work is to study the atomic arrangements in the slag glasses and to see whether any explanation for the degree of reactivity can be deduced from the structure. The work has so far been confined to glasses in the system $CaO—Al_2O_3—SiO_2$, and has aimed to produce sufficient material for compressive strength tests. A high-temperature furnace capable of reaching 1800 deg. C. has been built to melt and quench mixtures of up to 200 grammes. To assess the cementitious value, the quenched product is ground and tested for strength as a cement. There is a small-scale method for doing this, using ½-in. cubes in a compression test, but it would be preferable to find a method needing even smaller quantities of material. Measurements of the diamond pressure hardness, determined by the size of the impression made by a pyramidal-shaped diamond under standard conditions of loading, promise to be useful in this direction.

Hydration of Cement.

Work on the system lime-alumina-water is now completed. The phase relations are complicated by the fact that many of the phases occur in more than one structural form, and that further structural variations occur when the compounds formed in contact with solution are dehydrated. Of particular interest is the behaviour of $4CaO.Al_2O_3.19H_2O$, which, when removed from the solution, is

dehydrated easily to give a mixture of two forms of $4CaO.Al_2O_3.13H_2O$ with a resultant shrinkage along the c-axis of the crystal lattice. This may play a part in volume change of Portland cement products on wetting and drying. The work forms a basis for the examination of more complicated systems, which in turn are expected to provide information on the chemical processes in the setting and hardening of cements.

A study has been made of the volume stability, thermal expansion, compressive strength and modulus of elasticity of neat high-alumina and Portland cement pastes, and the relation of these properties to the degree of hydration at various temperatures and humidities.

Some concrete products, sand-lime bricks, and asbestos-cement or asbestos-lime products used as thermal insulation are bound together by a hydrated calcium silicate produced by autoclaving. On occasion, unexplained variations occur in the products and such variations are also reported by various investigators who have examined the system $CaO—SiO_2—H_2O$ under hydrothermal conditions. Recent work has shown that chemical equilibrium is obtained only after prolonged treatment at high pressures and that, within the times of autoclaving possible in practice, the product formed depends on the nature as well as on the composition of the starting materials. For example, different hydrated compounds are obtained from charges consisting of $2CaO+SiO_2$, β-$2CaO.SiO_2$ or $Ca(OH)_2+CaO.SiO_2.H_2O$, although all these have the same ratio of lime to silica.

In large masses of concrete large thermal stresses may be set up if the heat evolved in the setting of the cement causes the development of high temperatures within the structure. There is a standard procedure for determining the heat of hydration of Portland cements, but there are difficulties in its application to cements containing slags and pozzolanas. To meet this difficulty a new method has been devised and is at present the subject of a co-operative testing programme.

CEMENT

AND

LIME MANUFACTURE

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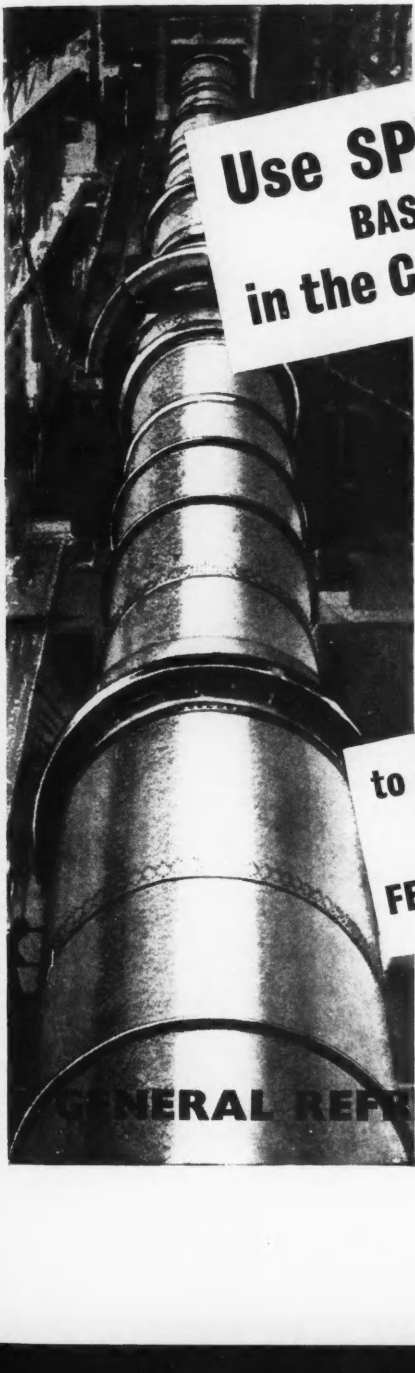
INDEX TO VOL. XXXII, 1959



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